Art. X.—*An Investigation of Fifty-Two Tasmanian Crania by Klaatsch's Craniotrigonometrical Methods.*

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When Huxley (1) write that he had arrived at the conclusion "that no comparison of crania is worth much that is not founded upon the establishment of a relatively fixed base line, to which the measurements in all cases could be referred," he considered that it would not be a very difficult matter to decide what that base line should be, and eventually suggested his now well-known basil-cranial axis. Many investigators have, however, employed modifications or adaptations of Huxley's basi-cranial axis, whilst others have devised totally independent base lines. The great objection, however, to the majority of these base lines is that they are non-correlative with any previous work, and when the next new base line appears, the others are, to a large extent, rendered valueless. Such a variety or multiplicity of methods creates unnecessary complications, and makes it impossible to obtain comparative data, and the result is, that notwithstanding the numerous craniological researches of the last fifty years, there has been but little appreciable advance in reducing these measurements to one common standard.

Bolk (2) considers that a rational base line of a craniometrical system must be able to serve for, at least, a primary division of the skull. In referring to the base lines which have been drawn through the base of the skull, he raises this objection, that whilst these base lines may be of value as boundary lines between the cerebral and facial skull, they are valueless as the basis of a craniometrical system. He thus criticises the base lines of Topinard, Aeby and Rauber. Sollas (3) writes that it is interesting to observe how closely in the consideration of base lines the latest researches have followed those first laid down by Huxley.

Considerable interest attaches to the methods instituted by Schwalbe (4), of Strassburg, on the calvaria of *Pithecanthropus erectus* particularly, and pre-historic man generally. In this work he employs as a base line the plane between the glabella and inion, that is, the plane previously associated with Rieger's name.

In selecting this plane, Schwalbe was compelled to make use of the glabella as one of the fixed points, owing to the fact that in calvaria of *Pithecanthropus erectus*, the face is missing, a remark which also applies to many of the other calvaria examined by Schwalbe, and which left him no choice in the matter. In deciding on this plan he says:—"so erweist sich als einfachste und natürlichste die vom vorderen Glabellarende bis zu dem am weitesten nach hinten vorragenden Medianpunkte des queren Hinterhauptwulstes, welchen Dubois als "scheinbares Inion" bezeichnet hat. Ich schlechthin als Inion bezeichnen werde."

In their researches on the Tasmanian crania, Berry and Robertson (5) also adopted, in the first place, Schwalbe's methods of "form analysis," based on the glabella inion plane, as they were anxious to institute comparisons of evolution between the Tasmanian and primitive man. Klaatsch (6), in his memoir on the Australian crania, also adopted the glabella inion plane. He says:—"To secure a common standard I take the glabellar point and glabellar inion plane," and again, "for purposes of the more precise comparative investigations with the fossil fragments, the glabella inion plane is clearly preferable." In his later works, however, he departs from the base line. Turner's (7) base line, that is, the nasio-tentorial plane, when available, appears to be one of the most satisfactory and rational planes for craniological purposes. In selecting this plane in opposition to the glabella inion plane, he states that the variation of the glabella, in association with the frontal sinus, "unfits it to be used for taking the point in front from which to estimate the length of the cerebral part of the cranial cavity."

Berry and Robertson (5) agree with Turner that the glabella inion plane is not the best (when others are available), "from which to estimate the cerebral part of the cranial cavity," but consider that "the nasio-inion plane coincides more closely with the cerebral part of the cranial cavity than either the glabella inion or nasio-tentorial planes."

The influence of the frontal sinus on the glabellar region has been carefully considered by many authors, notably Schwalbe (4, 8, 9), Logan Turner (10), Bianchi (11), Zuckerlandl (12) and Cunningham (13).

Cunningham considers that the relationship which exists between the sinus and glabella is a problem which must for the meantime remain unsolved.

As with the glabella, so also the position of the inion has been the subject of considerable investigation. Keith (14), Klaatsch (15), Sollas (3), Anderson (16), Rieger (17), Fraipont and Lohest (18), Kramberger (19), and others, all agree that variations exist in the positions of the external and internal protruberantia.

The choice of a base line is therefore, from every standpoint, a matter of difficulty, and no matter what the ultimate choice may be, it is clear that objections may be raised against it.

Notwithstanding the many base lines which have already been employed, Klaatsch (15 and 20) has recently introduced yet another method in order to secure a suitable standard basis for craniometrical observations. Whilst attempting to reconstruct the facial part of the Neandertal skull, he found that the glabella inion plane was not suitable for this purpose. He also found that when the skull is oriented in the Frankfort plane, the position assumed is not in harmony with the natural position of the head in the living subject, that is, with the eyes directed to the horizon.

On referring to Sollas's work on the Gibraltar skull, he found that that author had made use of median outline tracings of the cranial part of the skull minus the face, cut out in paper in order to establish the centre of gravity of the brain part of the cranium. Klaatsch reproduced this method, but as an experiment included the face as well. The centre of gravity now naturally fell further downward and forward, and to differentiate this new point from that of Sollas, Klaatsch designated the two points S and K respectively (Fig. 1), S being the centre of gravity as determined by Sollas, without the face, and K the centre of Klaatsch with the face.

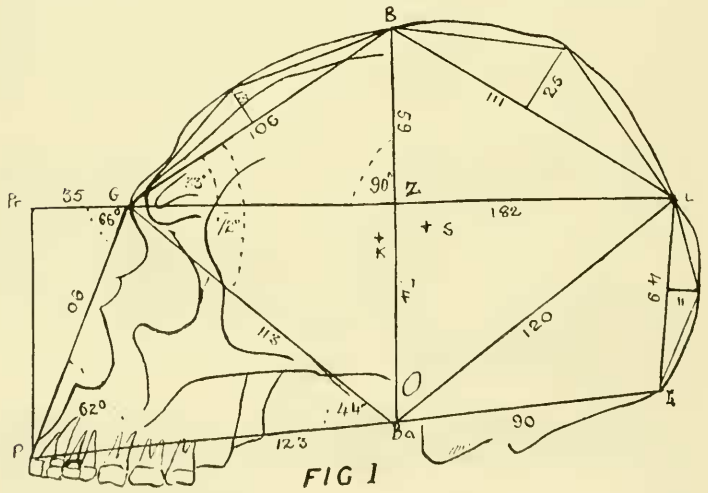

Fig. 1.—Sagittal diagram of an Australian Skull (Klaatsch). Half natural size.

K = Klaatsch's Gravitation Point.
S = Sollas's Gravitation Point.
Pr = Prognathic Point.

Z = Zentrum.
BGL = Upper Glabella Angle.
LGBa = Lower Glabella Angle.
BGBa = Anterior Glabella Angle.

On making further experiments Klaatsch was struck with the constant relationship which the point K bore to the basion bregma line, the point being always in that line, or a few millimetres to one or other side of it. On adding the glabella lambda line, Klaatsch noticed that it almost always intersected the basion bregma line at a right angle. The point of intersection he therefore terms the "Zentrum."

On account, therefore, of, firstly, the centre of gravity falling in, or close to, the basion bregma line; secondly, that line intersecting the glabella lambda line at a right-angled "Zentrum," and, lastly, the natural coincidence of this glabella lambda plane with the natural position of the head in life, Klaatsch proposes that this plane should be made the natural base line for all future craniometrical work. Upon this base line he further proposes that a quadrilateral figure should be devised, the sides of which are drawn from the glabella to the bregma, the bregma to the lambda, the lambda to the basion, and the basion to the glabella, respectively. These four lines, therefore, correspond in part, but not entirely, to the chords of the frontal, parietal and occipital bones, and the "basi-cranial" axis. On the four sides of this quadrilateral figure Klaatsch further proposes the erection of a series of triangles for the study of angles of curvature and other allied points in connection with the several bones of the skull.

The whole of this system he designates as a "craniotrigonometrical" method for studying the skull (Fig. 2). One advantage, amongst others claimed by its author for his method, is that the various angles will now receive their correct nomenclature, as Klaatsch, in common with others, has criticised Schwalbe's method of naming or misnaming these angles. Klaatsch, for example, proposes to obviate any confusion that may arise by designating angles by the position of their apices. He says: "Mein Prinzip ist jeden Winkel nach seinem Scheitelpunkte zu benennen." He thus terms the angle bounded by the bregma glabella and lambda glabella lines the upper glabellar angle. (See Fig. 2.)

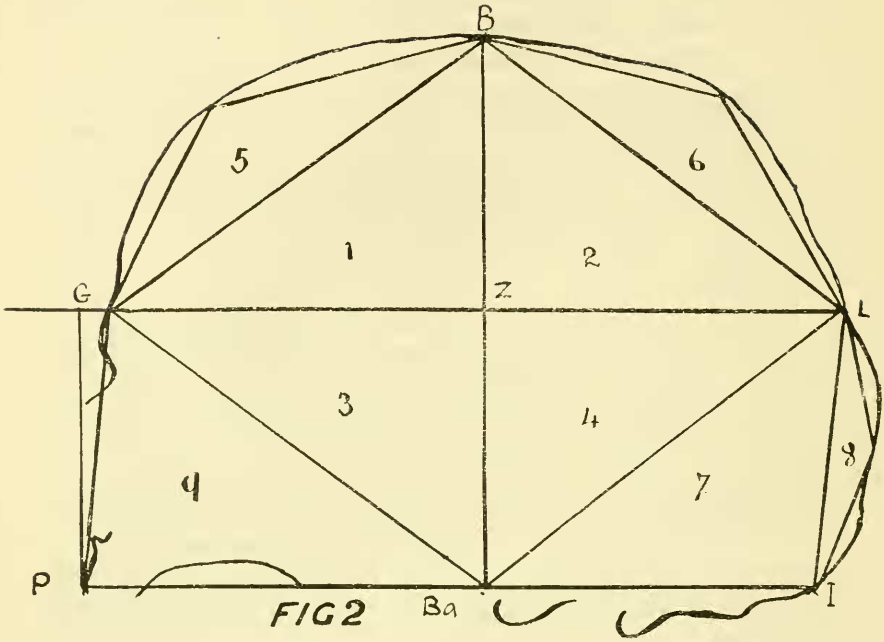

Fig. 2.— Illustrating Klaatsch's Craniotrigonometrical Method.
G = Glabella. B = Bregma. L = Lambda. I = Inion. Ba = Basion. P = Prosthion. S = Zentrum.
1-4 Inner Triangles. 5 Frontal Triangle. 6 Parietal Triangle. 7 Chief Occipital Triangle. 8 Adjacent Occipital Triangle. 9 Upper Facial Triangle.

It was suggested to me by Professor Berry, of Melbourne University, that I should apply this new craniotrigonometrical method of Klaatsch to the fifty-two Tasmanian crania previously examined by Dr. Robertson and himself (5) to ascertain if the methods just referred to as having been recently used by Klaatsch, were better adapted to the evolutionary morphology of the skull, than the older "form analysis" method of Schwalbe; and, in the second place, to ascertain if the several ranges of variation of the measurements to be recorded by this new method led to the same general conclusion as those obtained by the older method.

The material upon which this investigation is based will be found in Berry and Robertson's Dioptrographic Tracings in Four Normae of Fifty-two Tasmanian Crania (21). The present series of observations will be found in Norma A, that is, the medium sagittal tracing.

I have recorded in Table I., twenty-seven selected observations on every skull, where the natural condition of preservation enabled such to be recorded. The observations recorded are as follow:—

1. The glabella lambda length.
2. The glabella zentrum length.
3. The zentrum lambda length.
4. The basion bregma height.
5. The bregma zentrum height.
6. The zentrum basion height.
7. The angle at the zentrum.
8. The glabella bregma chord.
9. The bregma lambda chord.
10. The lambda basion chord.
11. The basion glabella chord.
12. The glabella bregma basion angle.
13. The lambda bregma basion angle.
14. The bregma lambda glabella angle.
15. The basion lambda glabella angle.
16. The lambda basion bregma angle.
17. The glabella basion bregma angle.
18. The basion glabella lambda angle.
19. The bregma glabella lambda angle.
20. The glabella bregma lambda angle.
21. The bregma lambda basion angle.
22. The lambda basion glabella angle.
23. The basion glabella bregma angle.
24. The lambda inion chord.
25. The inion basion length.
26. The basion prosthion length.
27. The prosthion glabella length.

As the nature of these twenty-seven can be easily followed from figure 2, in which they are displayed, it is unnecessary to describe them. Should more information be required as to their character and nature, the reader may be referred to Klaatsch's original works (15 and 20) dealing with his methods herein followed.

In Table I., I have followed the lines laid down by Berry and Robertson (5). This serial number, the present location of the skulls, and the original number are recorded in the upper three horizontal lines. In the three left-hand columns are set forth the numbers and the names of the recorded observations. In the vertical columns of serial numbers are set forth the individual numbers of each skull. The male and female skull measurements have been separated, and the results are, therefore, tabulated in separate columns. The four vertical columns on the right, after the male skull measurements, record

the number of observations made, the minimum and maximum figures for that particular observation, together with the average results. The results of the female skull measurements are likewise recorded in the columns to the right of the measurements, whilst the total results of the unsexed skulls will be found in the columns on the extreme right. The maximum and minimum figures have been indicated by a + or — sign in each row, and this method has been adopted uniformly throughout.

As was also the case in Berry and Robertson's work on these particular Tasmanian crania, it was not possible to record all of the observations upon every skull. Number 48 being a juvenile subject, the measurements recorded upon it have been uniformly omitted from the final results. In numbers 4 and 8, where the results concern the prosthion, they have also been omitted.

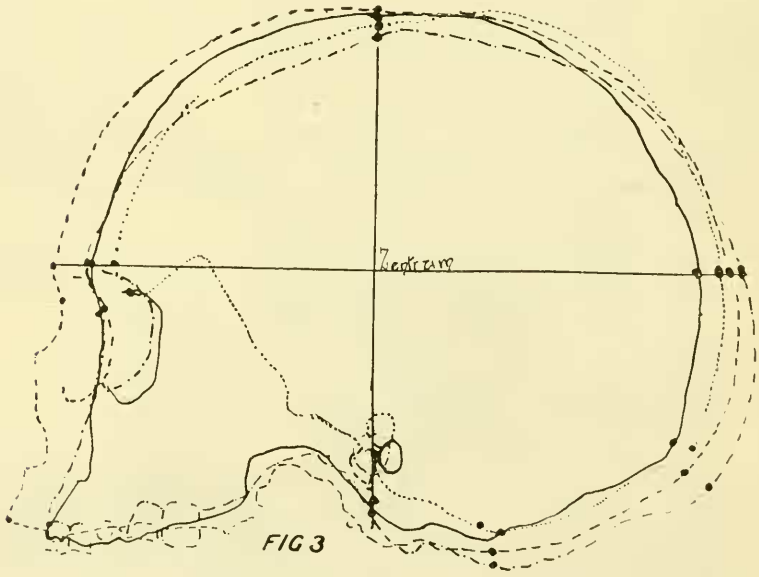

Fig. 3.—Four Tasmanian Crania superposed on Klaatsch's Base.

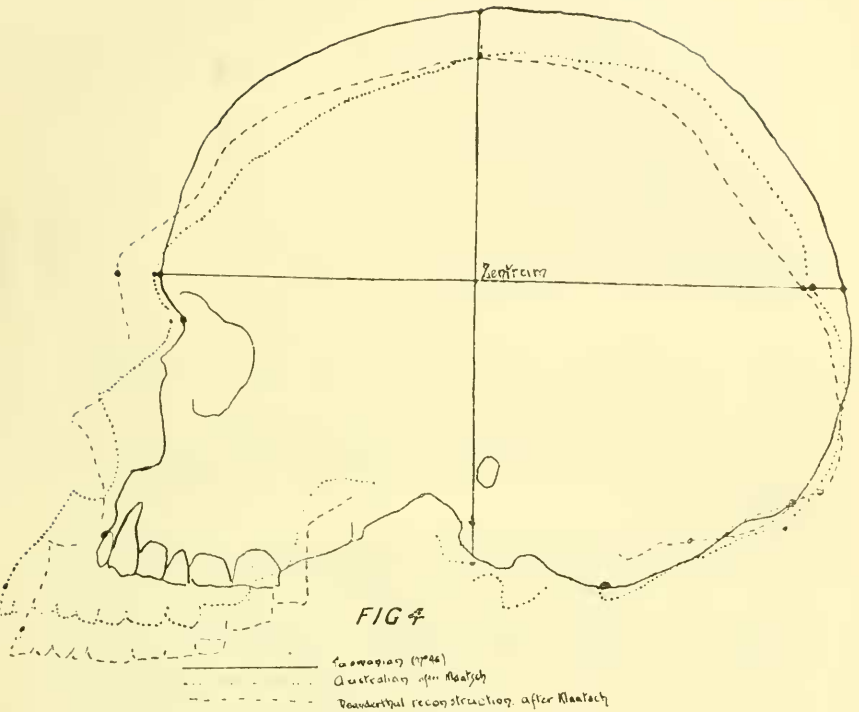

Fig. 4.—The Neanderthal (Klaatsch), Australian, and Tasmanian Skulls superposed on Klaatsch's Base.

Unfortunately no comparative data for this method are yet available, and so I can only record these observations without instituting any morphological or evolutionary comparisons. Klaatsch, however, records the measurements of one Australian (see Fig. 1), when the angle at the Zentrum is given at 90 deg., but Wetzel (22), on the other hand, found that in the Australian in no one of this three specimens was the angle of 90 deg.

In the Tasmanian, my investigations show that this Zentrum angle in over 25 per cent. of the crania examined, is exactly 90 deg., but it is obvious that in view of the insufficiency of numbers of the Australian, and the discrepant results obtained by Klaatsch and Wetzel from those numbers, no comparison can be instituted between my results for the Tasmanian, and those already mentioned for the Australian, and these apart, there are absolutely no other figures available.

The Tasmanian crania as drawn by Berry and Robertson (21), were "oriented in the Frankfort plane and then drawn by means of

Martin's Dioptrograph." The resulting diagrams are therefore strictly accurate and correlative.

Klaatsch, however, in his Australian work did not employ mechanical methods for fixation in the plane determined on, but used a yielding substance like plasticine. He says:—"In order to obtain exact results, the skull has to be carefully placed in proper position, it being essential that the tracing of its contour be made on the level of a definite common horizon." But the question arises, can a skull always be placed in its proper position without fixed mechanical methods? Personally I think not, and for this reason I have not availed myself of the diagrams furnished in Klaatsch's memoir on the Australian aboriginal, as it is open to doubt whether the orientation is absolutely reliable. Consequently, apart from the few comparative data of the "Zentrum" angle referred to, I do not propose to institute any further craniotrigonometrical comparisons between my Tasmanian results and those of other observers on the Australian.

I content myself, therefore, with leaving to those interested the further examination of the various figures now for the first time made available in Table I.

Concerning, therefore, the value of Klaatsch's craniotrigonometrical system, my investigation leads me to the belief that, for reconstructional work, such as that of the face from the calvaria, the method may be of some value, inasmuch as I have satisfied myself that in the Tasmanian, at all events, the angle formed by the basion bregma and glabella lambda lines is, as averred by Klaatsch, for all skulls, remarkably constant at or about 90 deg.

Apart from this the method does not appear to possess any advantage whatsoever, as compared with the existing method of Schwalbe. The latter method has been shown, notwithstanding its imperfections, and the fact as proved by Cross (23) that all its data are not of equal morphological value, to be of very real advantage for estimating the relative evolutionary growth of the brain, and of thus determining the relative positions of pre-historic and recent man of both low and high civilisations, one to another.

My final conclusion is, therefore, that greater progress will be made in the craniology of peoples by extending the observations of Schwalbe, Berry and Robertson, Cross and others to as many nationalities as possible, than by the invention of new methods.

Concerning the range of variations in the 27 observations herein recorded, it is important, in view of the attention now being almost generally devoted to this question, to examine it carefully.

Without going into the modern vexed question of the causes of variations and mutations, it may be stated that there are, at all events two widely divergent schools. The views of the one school

may be illustrated by a quotation from Thomson (24), who says, when speaking of the causes of variation: "In regard to the causes of variation it is too soon to speak, except in tentative whispers. What Darwin said must still be said, 'Our ignorance of the laws of variation is profound. Not in one case out of a hundred can we pretend to assign any reason why this or that part has varied.'"

The other line of thought may be illustrated by a quotation from Cossar Ewart (25), than whom there is no greater living authority on this particular subject. He says:—"Domestic animals reproduce themselves with great uniformity if kept apart; but the moment one mixed up the two different races, strains, or breeds, one did something that was difficult to put in words, the result was what has been best described as an 'epidemic' of variations."

The main question in dispute as to the origin of the Australian aboriginal is as to whether he is, or is not, an autochthonous race, that is, a pure-bred race, or the result of a cross, and in the Melbourne School of Anthropology, almost all the several lines of research laid down by Professor Berry have been evolved with the solution of this problem in view.

From what Cossar Ewart has said, it is clear that, if the Tasmanian be a pure-bred and homogeneous race, the range of variation should be small, whilst conversely if the Australian be an impure or mixed race the range of variation should be high. With the Australian I am not at present concerned, but the subject will shortly be dealt with by Professor Berry and Dr. Robertson.

Concerning the mode of studying the range of variation, provided there be some standard object of comparison, it is an easy matter to express the range of the variation of the subject under consideration in terms of percentage with the standard object, as is now actually being done by my fellow investigators in this school.

The results are not, as yet, quite ready for publication, but the work comprises a comparative study of the range of variation of "form analysis," and other cranial and facial measurements of supposed pure races like the Tasmanian and Andamanese, of known impure races like the modern Italian, and of the doubtful race under investigation, the Australian.

In my study of the craniotrigonometrical characters of the Tasmanian skull, it is obvious that as there are no other figures available to me, I cannot employ this particular method of studying the percentage range of variation, but have had to fall back on an ordinary arithmetical figure for displaying the mean range of variation. I am well aware that it is more accurate to employ the modern biometric methods, but in this particular case the final results of the one method are not materially different from those of the other.

I have therefore worked out the ranges of variation for the whole of the twenty-seven observations for the males, the females, and both sexes combined. I have subtracted the minimum range of variation from the mean, and the mean from the maximum, added all these differences together, and divided the quotient by fifty-four, that is, by twice the number of recorded observations, being once for the minima and once for the maxima.

The result is that in the twenty-seven craniotrigonometrical observations herein recorded, in fifty-two Tasmanian crania the range of variation is as follows:—

For males, 7.9.
For females, 7.5.
For both sexes, 9.9.

As, however, thirteen of my twenty-seven observations comprise angles only, in which the range of variation can never be appreciably great, I have again worked out the range of variation for those fourteen of the twenty-seven observations which do not comprise such angles, and with the following results:—

For males, 10.2.
For females, 9.9.
For both sexes, 10.1.

In either case the range of variation is so surprisingly small that it would seem to be reasonable to apply Ewart's dictum that "Animals reproduce themselves with great uniformity if kept apart," and to conclude by stating that the Tasmanian is a pure race. This conclusion is the more warranted, because when the results obtained by my colleagues, Drs. Berry and Robertson, are available, it will be found that they achieve identical results by different methods.

LITERATURE.

1. Huxley, T. H.—Man's Place in Nature, MacMillan and Co., 1897.
2. Bolk, L.—"On the Slope of the Foramen Magnum in Primates:" Reprint from Proceedings, Dec. 24th, 1909, of Koninklijke Akademie van Wetenschappen te Amsterdam.
3. Sollas, W. J.—"On the Cranial and Facial Characters of the Neandertal Race," Phil. Trans., B, vol. 199, 1907.
4. Schwalbe, G.—"Studien über Pithecanthropus erectus, Dubois," Zeit. für Morph. und Anthrop., Bd. I., 1899, pp. 16 et seq.
5. Berry, R. J. A., and Robertson, A. W. D.—"The Place in Nature of the Tasmanian Aboriginal, as Deduced from a Study of his Calvarium," Part I., Proc. Roy. Soc. Edinburgh, vol. xxxi., pt. 1, No. 3.

6. Klaatsch, Herman—Reports from Pathological Laboratory of the Lunacy Department of N.S.W., vol. i., pt. iii., 1908.

7. Turner, Sir W.—"The Craniology, Racial Affinities, and Descent of the Aboriginals of Tasmania." Trans. Roy. Soc. Edin., vol. xlvi., 1908, pp. 365-403.

8. Schwalbe, G.—"Der Neanderthalschädel," Bonner Jahrbücher, Heft 106, 1901.

9. Schwalbe, G. "Das Schädelfragment von Brüx und verwandte Schädelformen.' Zeit. für Morph. und Anthrop., Mai, 1906.

10. Turner, Logan—The Accessory Sinuses of the Nose, Edin., 1901.

11. Bianchi, —"J. seni frontali e le arcate sopraciliari studiate nei crani del delinquenti, degli alienati e dei normali," Archivio per l'antrop e l'etnologia, 1892.

12. Zuckerlandl, E. Normale und pathologische Anatomie der Nasenhöhle und ihre pneumatischen Anhänge, Bd. I., 2te Auflage, 1893.

13. Cunningham, D. J.—"The Evolution of the Eyebrow region of the Forehead, with Special Reference to the Excessive Supra-orbital Development in the Neandertal Race." Trans. Roy. Soc. Edin., vol. xlvi., pt. ii., No. 12.

14. Keith, Arthur—Ancient Types of Man, Harper's Living Thought Series, 1911.

15. Klaatsch, Herman—"Das Gesichtsskelet der Neandertalrasse und der Australier," Verhdlg. Anat. Ges., Berlin, 1908.

16. Anderson, R. J.—"Observations on the Thickness of the Human Skull," Dub. Journ. Med. Sci., vol. 74, 1882.

17. Rieger, C.—"Eine exacte Methode der Craniographie," Jena, 1885.

18. Fraipont and Lohest—"La race humaine de Neandertal ou de Canstadt en Belgique," Arch. de Biol., vol. 7, 1887.

19. Gorjanovic-Kramberger—"Der deviale Mensch von Krapina," Biol. Centralblatt, vol. 25, 1905.

20. Klaatsch, Herman—"Kraniomorphologie und Kraniotrigonometrie," Arch. für Anthrop., vol. 336, 190.

21. Berry, R. J. A., and Robertson, A. W. D.—"Dioptrographic Tracings in Four Normae of Fifty-two Tasmanian Crania," Trans. Roy. Soc. Vic., vol. v., 190.

22. Wëtzel, G.—"Die obersten Halswirbel und die Beziehung ihrer Ebenen zu denen des Schädels beim Menschen und den Anthropoiden." Zeit. für Morph. und Anthrop., Bd. xiii., Heft 2, 1910.

23. Cross, K. S.—"On a Numerical Determination of the Relative Position of certain Biological Types in the Evolutionary Scale, and of the Relative Values of various Cranial Measurements and Indices as Criteria. Proc. Roy. Soc. Edin., vol. xxxi., pt. 1, No. 4, 1910.

24. Thomson, J. A.—Heredity. Progressive Science Series, John Murray, 1908, p. 100.

25. Ewart, Cossar—"Discussion on Heredity in Disease," Scottish Med. and Surg. Journal, vi., 1900, p. 308.